



PCI - PIO

RoHS Compliant PCI Digital Input/Output Card

User Guide

Document Reference
Document Issue Level

Product User Guide
1.2

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Introduction

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About The Manual

This manual is organised into six chapters. Each chapter covers a different aspect of using the PCI-PIO. In order to get the best results from the product, the user is urged to read all chapters, paying particular note to Chapter 2 which deals with the initial installation of the card.

- Overview** Provides a brief introduction to the card
- Chapter 1** Presents the card's technical specification. Use this section to determine the card's suitability for a particular application
- Chapter 2** Explains how to install the card in your computer.
- Chapter 3** Details the connections to and from the card
- Chapter 4** Gives details of the card's address mapping and internal register details allowing the user to write custom software to control the card.
- Chapter 5** Electromagnetic Compatibility
- Chapter 6** Shows typical Input and Output circuitry

This manual describes the complete hardware functionality of the PCI-PIO board. All the functions may not necessarily be supported by the current release of the driver.

Overview

The PCI-PIO is a RoHS-compliant PCI-compatible half-card which provides digital input/outputs and counter/timers.

There are 48 TTL-compatible programmable digital input/outputs available from the board. If the controlling devices are used in handshake mode, the handshake lines are available as interrupt sources.

There are also three programmable counter/timers, the enable and clock inputs being available externally, if required, and the outputs being accessible externally or as interrupt sources. A 4MHz crystal oscillator is available on board to allow the counter/timers to act as accurate timebases.

All input/output lines are available at an industry standard 50 way D-type plug connector.

One PCI interrupt line may be selectively driven by the seven interrupt sources on the board, the interrupting source being readily identified by the board.

The PCI-PIO is intended to be installed with the minimum of user interaction. The board is configured by the system BIOS and by the application drivers and no on-board links are required to select functionality.

Chapter 1

Technical Specification

Number Of I/O Channels	48 arranged as 2 x 3 x 8 I/O bits
Signal Levels	5 Volt TTL Logic levels
Outputs:	
Logic Low Level:	0 Volts (min) – 0.4 Volts (max) @ $I_{OL} = 2.5 \text{ mA}$
Logic High Level:	3.5 Volts (min) – 5 Volts (max) @ $I_{OH} = -400\mu\text{A}$
Drive Current:	2.5 mA. (Logic Low) $V_{out} = 0.4 \text{ Volts}$ -400 μA (Logic High) $V_{out} = 3.5 \text{ Volts}$
Input Loading:	-10 μA (Logic Low) +10 μA (Logic High)
Counter/Timers:	3 x 16 Bit. Counter/timers 0, 1 and 2 may be cascaded to provide a single 48 bit Counter/timer All Counter/timers may be clocked externally at a maximum rate of 4 MHz
On board Oscillator:	Frequency 4Mhz 4 PIO handshake control Lines
Interrupt Sources:	Register selectable to 3 Counter/timer outputs and 4 PIO handshake control lines
Interrupt Levels Supported:	All PCI interrupts
Address Overhead	16 contiguous addresses in 16 byte block
Board Power Requirement:	1.6W This board requires both 5V and 3V3 power lines but it will operate with Vio of either 3.3V or 5V
Temperature:	
Non Operating:	-20 °C to 70 °C
Operating:	0 °C to 70 °C
MTBF:	500,000 hours (Bellcore method)
Signal Connections:	1 x 50 way male “D-type” plug
Dimensions	125 (L) x 91 (H) board only 135 (L) x 122 (H) x 22 (W) including bracket

Chapter 2

Installing the PCI-PIO

The card is installed by removing the cover of the host computer and inserting the card into a free PCI slot. The rear panel of the card should then be secured to the rear panel of the host computer with the screw supplied with the computer.

When the computer is switched on, the BIOS will detect the presence of the card and will allocate it with a base address and an interrupt. These parameters may then be used to configure application software to access the card.

If the card is to be directly accessed by a user's application, it will be necessary for the application to determine where the BIOS has located the card.

One way of determining the Base address of the card can be found by using the "bc_probe" utility which is supplied on the Blue Chip Support CD, or alternatively can be downloaded from the Blue Chip website

This program must be run under DOS or a Full Screen session under Windows. It will not operate in a DOS Window.

The BC_probe utility will return addresses which look like the following

```
bar1, IO, 0xC800  
bar2, IO, 0xC400
```

The Bar 1 address just sets up address space in memory to be used by the card while the Bar 2 address is the base address for the Registers for the card.

These can be used as follows in conjunction with the Address map on page 12 of this user manual.

```
Base+0 PIO 1 Port A Input/Output Register R/W >> 0xC400  
Base+1 PIO 1 Port B Input/Output Register R/W >> 0xC401  
...  
Base+F5 Counter Control Register B R/W >> 0xC40F
```

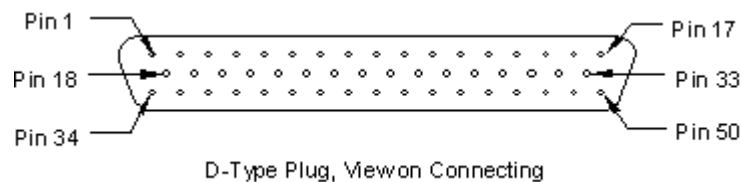
Chapter 3

Connection Details

The following table refers to the 50 way D-type plug on the rear of the card

PIN	USAGE	PIN	USAGE	PIN	USAGE
1	PIO1 port A, b0 (PAA0)	18	PIO1 port C, b1 (PAC1)	34	PIO2 port B, b1 (PBB1) or Counter I/O
2	PIO1 port A, b1 (PAA1)	19	PIO1 port C, b2 (PAC2)	35	PIO2 port B, b2 (PBB2) or Counter I/O
3	PIO1 port A, b2 (PAA2)	20	PIO1 port C, b3 (PAC3) and/or interrupt source or Counter I/O	36	PIO2 port B, b3 (PBB3)
4	PIO1 port A, b3 (PAA3)	21	PIO1 port C, b4 (PAC4)	37	PIO2 port B, b4 (PBB4)
5	PIO1 port A, b4 (PAA4)	22	PIO1 port C, b5 (PAC5)	38	PIO2 port B, b5 (PBB5)
6	PIO1 port A, b5 (PAA5)	23	PIO1 port C, b6 (PAC6)	39	PIO2 port B, b6 (PBB6)
7	PIO1 port A, b6 (PAA6)	24	PIO1 port C, b7 (PAC7)	40	PIO2 port B, b7 (PBB7)
8	PIO1 port A, b7 (PAA7)	25	PIO2 port A, b0 (PBA0)	41	PIO2 port C, b0 (PBC0) and/or interrupt source or Counter I/O
9	PIO1 port B, b0 (PAB0)	26	PIO2 port A, b1 (PBA1)	42	PIO2 port C, b1 (PBC1)
10	PIO1 port B, b1 (PAB1)	27	PIO2 port A, b2 (PBA2)	43	PIO2 port C, b2 (PBC2)
11	PIO1 port B, b2 (PAB2)	28	PIO2 port A, b3 (PBA3)	44	PIO2 port C, b3 (PBC3) and/or interrupt source or Counter I/O
12	PIO1 port B, b3 (PAB3)	29	PIO2 port A, b4 (PBA4)	45	PIO2 port C, b4 (PBC4)
13	PIO1 port B, b4 (PAB4)	30	PIO2 port A, b5 (PBA5)	46	PIO2 port C, b5 (PBC5)
14	PIO1 port B, b5 (PAB5)	31	PIO2 port A, b6 (PBA6)	47	PIO2 port C, b6 (PBC6)
15	PIO1 port B, b6 (PAB6)	32	PIO2 port A, b7 (PBA7)	48	PIO2 port C, b7 (PBC7)
16	PIO1 port B, b7 (PAB7)	33	PIO2 port B, b0 (PBB0) or Counter I/O	49	Digital Ground
17	PIO1 port C, b0 (PAC0) and/or Interrupt source or Counter I/O			50	Digital Ground

The following diagram shows how the pins on the male D-type connector are numbered



If you are having difficulty in obtaining suitable cables to attach to the PCI-PIO, the Farnell part numbers for suitable connectors are 1084683 and 4155312.

Suitable Interface Signal Types

The input and output signals for the PCI-PIO parallel ports and counter/timers are strictly digital TTL levels with voltage limits of zero volts for a logic low and +5 volts for a logic high. Voltages outside these limits may cause damage to the card. The output current drive capability makes the card suitable for connection to TTL logic type circuits. The PCI-PIO is compatible with most types of TTL logic. Because the lines are TTL it is recommended that input signal lines do not exceed 2 metres in length. Operation at longer lengths may cause drive level problems.

Driving conventional relay coils is not recommended without external protection even if the coil current required is less than the PCI-PIO can provide. Relay coils are inductive and as such can generate large flyback voltages when de-energised which will destroy the device outputs.

Chapter 4

This chapter provides brief details of the cards internal registers.

The board's input/output facilities are provided by two Intel i8255 PIO devices and an Intel i8254 Counter/timer

Each PIO provides 24 programmable digital I/O channels. It is suitable for sensing the presence of, or driving TTL connections only. These connections should be kept as short as possible, less than 2 metres is recommended.

Each PIO appears to the PC as four I/O addressable registers. The first three registers control the I/O ports which can be set as input or output by writing suitable codes to the fourth Control Port.

Three modes of operation are available within the device:-

Mode 0 is for general purpose I/O and allows all three ports to be configured as either inputs or outputs.

Mode 1 is for full duplex parallel communication and allows one port to be configured for inputs, another for outputs and the third as transfer handshake lines and interrupt sources.

Mode 2 is for half duplex parallel data communication, and allows one port to be configured for data transfer I/O, a second as transfer handshake lines and an interrupt source, and the third as a general purpose I/O port (similar to mode 0).

For mode 0, a summary of the codes required to change the operation of the ports are given later. A typical sequence of events to use this feature would be :

- Decide on the mix of input/outputs required and write the appropriate code to the Control Register.
- Read from the selected input port or write to the selected output port.

The 8254 contains three 16-bit Counter/timers each of which has separate clock and enable inputs and an output, all of which are TTL compatible. Connections to these signals should be kept as short as possible, less than 2 metres is recommended.

The 8254 appears to the PC as four ports. The first three are count registers for the three counter/timers, and the fourth is a Control Register which configures the mode of operation of the three counters. These are accessed at the addresses shown in the map below.

A summary of the codes required to change the port operations are given later.

Address Map

The address map for the PCI-PIO occupies a 16-byte block of addresses.

All the following addresses are relative to PCI base address register 2, located at address 18 (hex) in the PCI configuration space.

ADDRESS	FUNCTION	READ/ WRITE
Base + 0	PIO 1, Port A Input/Output Register (Channel 0 to 7)	R/W
Base + 1	PIO 1, Port B Input/Output Register (Channel 8 to 15)	R/W
Base + 2	PIO 1, Port C Input/Output Register (Channel 16 to 23)	R/W
Base + 3	PIO 1, Control Register	W
Base + 4	PIO 2, Port A Input/Output Register (Channel 24 to 31)	R/W
Base + 5	PIO 2, Port B Input/Output Register (Channel 32 to 39)	R/W
Base + 6	PIO 2, Port C Input/Output Register (Channel 40 to 47)	R/W
Base + 7	PIO 2, Control Register	W
Base + 8	Counter/timer 0 Count Register	R/W
Base + 9	Counter/timer 1 Count Register	R/W
Base + A	Counter/timer 2 Count Register	R/W
Base + B	Counter/timer Control Register	W
Base + C	Interrupt enable register	R/W
Base + D	Interrupt status register	R
Base + E	Counter control register A	R/W
Base + F	Counter control register B	R/W

The i8255 PIO and i8254 Counter/timer ICs are complex devices. For full details on how to program these devices, refer to the manufacturer's data sheets. Presented here is a brief summary of the main features of each.

i8255 PIO

The PIO chip can operate in one of three modes.

The first (Mode 0) provides for simple inputs and outputs for three, 8-bit ports. Data is written to or read from a specified port (A, B, or C) without the use of handshaking. The following table gives a summary of the most commonly used control words which must be written to the control port to configure the i8255 I/O ports in Mode 0.

CONTROL WORD (hex)	CONTROL WORD (decimal)	SET ALL of PORT A as	SET ALL of PORT B as	SET HIGH 4 BITS of C as	SET LOW 4 BITS of C as
80	128	Output	Output	Output	Output
81	129	Output	Output	Output	Input
82	130	Output	Input	Output	Output
83	131	Output	Input	Output	Input
88	136	Output	Output	Input	Output
89	137	Output	Output	Input	Input
8A	138	Output	Input	Input	Output
8B	139	Output	Input	Input	Input
90	144	Input	Output	Output	Output
91	145	Input	Output	Output	Input
92	146	Input	Input	Output	Output
93	147	Input	Input	Output	Input
98	152	Input	Output	Input	Output
99	153	Input	Output	Input	Input
9A	154	Input	Input	Input	Output
9B	155	Input	Input	Input	Input

Mode 1 enables the transfer of data to or from a specified 8 bit port (A or B) in conjunction with strobes or handshaking signals on port C. These handshaking signals may be used to drive interrupt channels if required.

In Mode 2, data is transferred via one bi-directional 8 bit port (A) with handshaking (port C). These handshaking signals may be used to drive interrupt channels if required.

Refer to the i8255 data sheet for full details of the settings and use of Modes 1 and 2.

i8254 Counter / Timer

The counter/timer circuit contains three independent 16-bit counters which may be operated in a variety of modes. There are five basic modes of operation with each mode providing a different output signal. Presented here is a brief summary of some of the modes possible by programming the counter / timer's internal registers.

All three counter/timers may be operated independently, with separate clocks and enable controls.

Counter 0, Counter 1 and Counter 2 may be connected in series. Counter 0 output to Counter 1 clock input and/or Counter 1 output to Counter 2 clock input, to allow the facility of generating very long delay periods.

The outputs from any counter/timer may be configured to generate an interrupt when going high or low, and may also be made accessible on the back panel connector.

The clock and enable inputs of the counter/timers may also be made accessible on the back panel connector.

Counter / Timer Modes

The following modes of operation exist by programming the control register within the i8254. N.B. The interrupts may be generated when the Counter/timer outputs go low or high, selected by bits in the counter control registers.

Mode 0

When programmed, the output pin will go LOW. When the counter decrements from the value loaded into the count registers to zero, the output pin will go HIGH. It will remain high until the count is re-programmed into the count registers.

Mode 1

When the count registers are programmed the output pin will be HIGH. When a LOW going signal is applied to the gate input, the count starts and the output will fall LOW, returning HIGH at the end of the count.

Mode 2

This mode operates as a frequency divider. When programmed the output pin is HIGH. When the count decrements to a value of 1 the output pin will go LOW for ONE clock cycle only and then return HIGH. This cycle repeats continuously without the need to re-program the count value.

Mode 3

When programmed the output pin will toggle each time the count register decrements to its base level from the value programmed into it. If the count value loaded is an odd number then the counter will reach zero before the output pin toggles. This mode therefore acts as a frequency divider with an approximate 1:1 mark-space ratio.

Mode 4

This mode is similar to mode 2 but the output pin pulses when the count reaches zero instead of 1.

Mode 5

This mode is similar to mode 4 except that the count sequence is triggered by the gate line.

Counter Control

The control and output lines of the counter/timer may be accessed on the rear panel connector by sacrificing some of the digital I/O lines.

The clock inputs of the i8254 counter/timer are selected using the Counter Input Select Register A at Base + E (Hex), as shown below:-

Counter Input Select Register A (Base + E)		CISR_A
Bit no.	Function	
b7	Enable counter outputs such that PBB0 = Counter 2 output PBB1 = Counter 0 output PBB2 = Counter 1 output	
b6	Counter 0 interrupt level:- 0 = Interrupt on counter out low 1 = Interrupt on counter out high	
b5..b4	Counter 2 clock source:- 00 = 4 MHz oscillator 01 = PBB2 port line 10 = Counter 1 output 11 = PBC0 port line	
b3..b2	Counter 1 clock source:- 00 = 4 MHz oscillator 01 = PBB1 port line 10 = Counter 0 output 11 = PAC3 port line	
b1..b0	Counter 0 clock source:- 00 = 4 MHz oscillator 01 = PBB0 port line 10 = Counter 2 output 11 = PAC0 port line	

If Bit b7 in the counter control register is set, then the counter outputs are enabled onto port lines PBB0, PBB1 & PBB2, which connect to the 50 way D-type connector. Consequently this port must be set as an input in the relevant i8255 device to avoid contention. This same condition applies to any port line which is used for a counter/timer function.

The enable inputs of the i8254 counter are selected using the Counter Input Select Register B at Base + F (Hex), as shown below:-

Counter Input Select Register B (Base + F)		CISR_B
Bit no.	Function	
b7	Counter 2 interrupt level:- 0 = Interrupt on counter out low 1 = Interrupt on counter out high	
b6	Counter 1 interrupt level:- 0 = Interrupt on counter out low 1 = Interrupt on counter out high	
b5..b4	Counter 2 enable source:- 00 = Permanently enabled 01 = PBB1 port line 10 = PBC0 port line 11 = PBC3 port line	
b3..b2	Counter 1 enable source:- 00 = Permanently enabled 01 = PBB0 port line 10 = PAC3 port line 11 = PBC0 port line	
b1..b0	Counter 0 enable source:- 00 = Permanently enabled 01 = PBB2 port line 10 = PAC0 port line 11 = PAC3 port line	

Notice that it is possible by judicious setting of Counter Input Registers A and B, to set each timer/counter to operate with an external count input, enable and counter output if required. For example it is possible to set Counter 0 to use PBB0 as a count input, PBB2 as an enable input, and PBB1 as a count output. Other combinations are possible, but because of the flexibility which is permitted, care must be exercised to avoid conflicting uses of the same port lines.

Interrupt Selection

A total of seven sources of interrupt are available from the two PIO devices and the counter/timers. These interrupts are summarised below:-

- INT1 (AC0) is available when PIO1 is operating in mode 1. It provides a Read Request interrupt for input operations or a Write Request interrupt for output operations on PIO1 port A (PAA[0:7]).
- INT2 (AC3) is available when PIO1 is operating in mode 1. It provides a Read Request interrupt for input operations or a Write Request interrupt for output operations on PIO1 port B (PAB[0:7]).
- INT3 (BC0) is available when PIO2 is operating in mode 1. It provides a Read Request interrupt for input operations or a Write Request interrupt for output operations on PIO2 port A (PBA[0:7]).
- INT4 (BC3) is available when PIO2 is operating in mode 1. It provides a Read Request interrupt for input operations or a Write Request interrupt for output operations on PIO2 port B (PBB[0:7]).
- INT5 is the output from Counter/timer 0, and may be used to generate interrupts on timed events.
- INT6 is the output from Counter/timer 1, and may be used to generate interrupts on timed events.
- INT7 is the output from Counter/timer 2, and may be used to generate interrupts on timed events.

The use of interrupts is not essential but greatly enhances the functionality of the card.

To enable the generation of an interrupt or a combination of interrupts, an enable word must be written to the Interrupt Enable Register at Base + C (Hex), as shown below:-

Interrupt Enable Register (Base + C) IER	
Bit no.	Function
b7	Not used
b6	Counter/timer 2 interrupt control (1 = Enable, 0 = Disable)
b5	Counter/timer 1 interrupt control (1 = Enable, 0 = Disable)
b4	Counter/timer 0 interrupt control (1 = Enable, 0 = Disable)
b3	Port BC3 interrupt control (1 = Enable, 0 = Disable)
b2	Port BC0 interrupt control (1 = Enable, 0 = Disable)
b1	Port AC3 interrupt control (1 = Enable, 0 = Disable)
b0	Port AC0 interrupt control (1 = Enable, 0 = Disable)

When an interrupt is recognised by the processor, the source or sources of interrupt may be read from the Interrupt Status Register at Base + D (Hex), as shown below:-

Interrupt Status Register (Base + D) ISR	
Bit no.	Function
b7	Not used
b6	Counter/timer 2 interrupt occurred
b5	Counter/timer 1 interrupt occurred
b4	Counter/timer 0 interrupt occurred
b3	Port BC3 interrupt control occurred
b2	Port BC0 interrupt control occurred
b1	Port AC3 interrupt control occurred
b0	Port AC0 interrupt control occurred

Having serviced an interrupt, the source may be cleared by momentarily clearing the relevant bit in the Interrupt Enable Register.

The diagram following demonstrates the various ways in which the counter/timers may be interconnected and the registers and bits that control them.

PCI-PIO COUNTER/TIMER CONFIGURATIONS

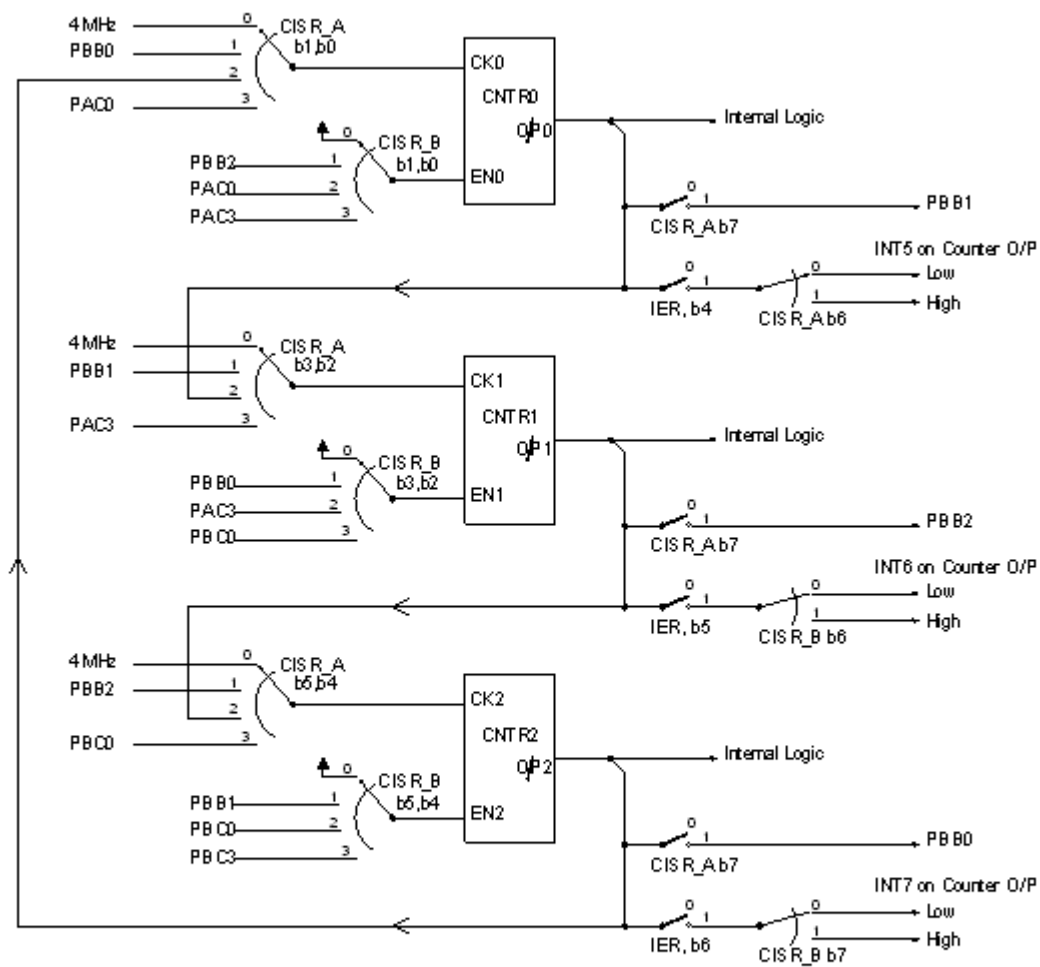


Diagram shows the Software Registers, Bit Numbers and Bit Values, e.g. CIS R_B b3,b2

Also shown are Programmable I/O Port and Bit Numbers as shown in the Connections Table, e.g. PAC3

Chapter 5

Electromagnetic Compatibility (EMC)

This product meets the requirements of the European EMC Directive (89/336/EEC) and is eligible to bear the CE mark.

It has been assessed operating in our standard industrial PC. However, because the board can be installed in a variety of computers, certain conditions have to be applied to ensure that the compatibility is maintained. It meets the requirements of EN55022:1995 for a Class A product subject to those conditions.

- The board must be installed in a computer system which provides screening suitable for an industrial environment.
- Any recommendations made by the computer system manufacturer/supplier must be complied with regarding earthing and the installation of boards.
- The board must be installed with the backplate securely screwed to the chassis of the computer to ensure good metal-to-metal (i.e. earth) contact.
- Most EMC problems are caused by the external cabling to boards. It is imperative that any external cabling to the board is totally screened, and that the screen of the cable connects to the metal end bracket of the board and hence to earth. It is recommended that round screened cables with a braided wire screen are used in preference to those with a foil screen and drain wire. Use metal connector shells which connect around the full circumference of the screen; they are far superior to those which earth the screen by a simple “pig-tail”. Standard ribbon cable will not be adequate unless it is contained wholly within the cabinetry housing the industrial PC.
- Ensure that the screen of the external cable is bonded to a good RF earth at the remote end of the cable.
- Cables which connect externally to boards at TTL levels should not exceed two metres in length.

Failure to observe these recommendations may invalidate the EMC compliance.

Warning

This is a Class A Product. In a domestic environment this product may cause radio-interference in which case the user may be required to take adequate measures.

EMC Specification

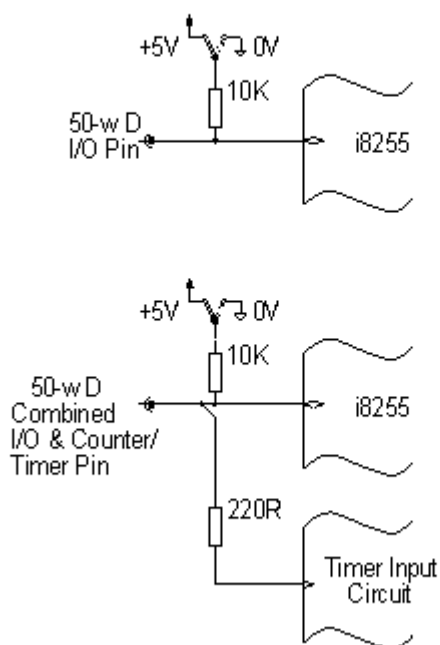
A suitably compliant industrial PC fitted with this card meets the requirements of the European Union Electromagnetic Compatibility Directive 89/336/EEC and its amending Directives, and specifically the following standards:

Emissions	EN 55022:1998 Class A
Immunity	EN 55024:1998

Chapter 6

Typical Input and Output Connections to the PIOs and the Counter/Timers

PCI-PIO Input / Output Circuitry



Note that whilst the i8255 port is shown above as an input device, it may also be programmed as an output device. Under these circumstances the pull-up/down resistor will act as a load.

If using one of the common input pins as an input to the Timer, care must be taken to set the i8255 port as an input to avoid conflict, otherwise the external input at the pin will be in conflict with the output of the output port.

Amendment History

Issue Level	Issue Date	Author	Amendment Details
1.0	15/01/2007	Tmck	Initial Release
1.1	07/02/2007	TMCK	Added MTBF figures and minor grammar changes made, corrected EMC details
1.2	21/03/2007	TMCK	Corrected Reversed Drawings

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